CLINICAL INVESTIGATIONS

Out-of-Hospital Administration of Albuterol for Asthma by Basic Life Support Providers

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Abstract

Background: Each year, approximately 40,000 patients with acute asthma are transported by the Fire Department of New York City (NYC) Emergency Medical Services (EMS). Out-of-hospital administration of bronchodilator therapy has, however, been restricted by scope of practice to advanced life support (ALS) providers. Since the rapid availability of ALS units cannot always be assured, some individuals with acute asthma may receive only basic life support (BLS) measures in the field. **Objectives:** To demonstrate that basic emergency medical technicians (EMT-Bs) are able to effectively administer nebulized albuterol to asthma patients in the out-of-hospital environment. **Methods:** This was a prospective, observational cohort study of 9-1-1 asthma calls received by the NYC EMS system for patients between the ages of 1 and 65 years. Baseline peak expiratory flow rate (PEFR) and other clinical measures were obtained prior to and following BLS administration of one or two treatments with nebulized albuterol. **Results:** Data were available for 3,351 patients over a one-year study period. One out-of-hospital albuterol treatment was given in 60%, while 40% of the patients received two. The PEFRs increased from 40.4% predicted (SD ±21.0) to 54.8% predicted (SD ±26.1), for a posttreatment improvement of 14.4% points (95% CI = 13.8 to 15.1). Other clinical outcome measures, including dyspnea index, respiratory rate, and use of accessory muscles, also showed improvement. **Conclusions:** This study demonstrates that EMT-Bs can effectively administer albuterol to acute asthma patients in the out-of-hospital environment. **Key words:** asthma; acute disease; albuterol; prehospital emergency care; services, emergency medical. ACADEMIC EMERGENCY MEDICINE 2005; 12:396–403.

In New York City (NYC), more than 40,000 people who have asthma are transported each year in response to calls to the 9-1-1 system. As is the case in many emergency medical services (EMS) systems, administration of pharmacologic bronchodilator therapy is restricted by scope of practice to higher-level paramedic or other advanced life support (ALS) providers, who are trained in medication administration. However, while the majority of asthma patients might benefit from out-of-hospital bronchodilator therapy, the rapid availability of paramedic or other ALS units cannot always be assured. As a result, certain asthma patients may receive only basic life support (BLS) measures from basic emergency medical technicians (EMT-Bs) prior to the arrival of ALS, or prior to transport to a receiving hospital facility. Since pharmacologic intervention by EMT-Bs has previously been limited to oxygen administration, an expanded scope of practice for these BLS providers might be of particular benefit to this population of patients with previously limited access to such care. While the efficacy and safety of bronchodilator therapy in the treatment of asthma-induced bronchospasm have been clearly demonstrated, little attention has focused on the use of such agents by BLS providers in the out-of-hospital environment. Furthermore, there has been a paucity of attempts to test or challenge currently accepted dogma on out-of-hospital scope of practice.

A one-year demonstration project that incorporated administration of beta-agonists by BLS units to asthma patients as standard care was conducted in NYC. In this study we report the ability of BLS providers to effectively administer β-agonists to acutely ill asthma patients in the out-of-hospital setting.

METHODS

Study Design. This was a prospective, observational cohort study of 9-1-1 asthma calls received by the NYC EMS system for patients between the ages of 1 and 65 years. The Fire Department of New York and the institutional review board of Long Island Jewish Medical Center approved this study. The investigational review board waived the requirement for written informed consent.

Study Setting and Population. This study was based on a one-year citywide demonstration project

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in which BLS providers administered inhaled β-agonists to acutely ill asthmatic patients who requested EMS assistance through 9-1-1.

The NYC Fire Department EMS system provides out-of-hospital emergency medical care to more than 8 million residents in the 300-square-mile New York metropolitan area. This three-tier system employs approximately 700 paramedics (ALS), 2,200 emergency medical technicians (BLS), and 7,000 firefighters who are certified first responder/defibrillator-trained. At any time, there are approximately 250 ambulance response units in the street, handling more than 1 million calls and more than 750,000 transports each year. Patients are brought to one of sixty 9-1-1 receiving hospitals, and 30% of these calls utilize a paramedic ALS response. Field providers operate under uniform out-of-hospital care protocols established by regional and state emergency advisory councils. There are seven full-time physicians who provide medical oversight, and an additional ten physicians who provide staffing for a full-time, central online medical control facility.

Data were collected prospectively on the one-year consecutive sample of patients for whom an EMT-B was the initial responder. The systemwide EMS generic ambulance call report (ACR) was modified to collect data for this demonstration project (printed on all ACRs were supplementary asthma questions). BLS providers administered unit-doses of albuterol sulfate 0.083% (3.0 mL) by small-volume nebulizer with 100% oxygen, at a flow rate to deliver the solution over 5 to 15 minutes. Out-of-hospital BLS crews were instructed to administer up to two treatments. Contact with online medical control was required prior to treating any patient with a history of angina, myocardial infarction, arrhythmia, or congestive heart failure. Following initial evaluation or at any time during management, out-of-hospital crews were instructed to request ALS backup for any patient in severe respiratory distress.

Patients between the ages of 1 and 65 years with complaints of difficulty breathing secondary to a history of previously diagnosed asthma, for whom BLS units were dispatched when ALS units were not available, were eligible for inclusion, as were patients who self-administered β-agonists before EMS arrival. Patients with any of the following were excluded: resolution of symptoms upon EMS arrival, treatment in progress upon EMS arrival, albuterol allergy, or signs of imminent respiratory failure. Patients whose care was comanaged by an available ALS unit subsequently dispatched to the scene were also excluded from the data analysis.

Study Protocol

Training. Approximately 2,200 EMT-Bs were trained in the utilization of a new BLS asthma protocol (Figure 1), as well as in the patient assessment and documentation requirements of the study. A didactic component was presented on the pathophysiology and clinical presentation of asthma, with special focus on differentiating acute respiratory distress from acute respiratory failure. Patient assessment measures, including proper use of the peak flow meter and a subjective dyspnea index, were practiced in real-time clinical scenario and skills sessions. The pharmacology, preparation, and administration of the study medication, albuterol, were covered in both the didactic and skills components of the curriculum. Operational guidelines regarding documentation, tracking, and restocking of medication were carefully detailed. Out-of-hospital providers were evaluated on their clinical skills, as well as their performance, on a written examination. The entire EMT-B force was trained in four-hour sessions over a period of approximately three months.

Methods of Measurements. Subjective (a modified Borg method,[1] incorporating a visual analog scale with verbal descriptors, ranging from 0 [no symptoms] to 10 [severe symptoms]) and objective (peak expiratory flow rate [PEFR], respiratory rate, pulse, blood pressure, accessory muscle use, and ability to speak in full sentences) patient assessment measures were documented before and after treatment. Peak flow measurements were made with a TruZone peak flow meter (Monaghan Medical Corporation, Plattsburgh, NY). The best of three attempts were recorded pre- and posttreatment. Posttreatment measures were generally performed while en route to the hospital or immediately upon ED arrival. Peak flow measurements and dyspnea assessments were attempted in patients aged 5 years and older.

Data Collection and Processing. In order to track, dispatch, and appropriately enter patients into the protocol, a new call-receiving operator (CRO) algorithm (Figure 2), and two new call types (ASTHMA [age ≥15 years] and ASTHMP [age <15 years]) were implemented. BLS crews were dispatched to either of these calls only when an ALS response unit was not available. Whereas most ASTHMA/ASTHMP patients were identified at the point of contact with the CRO, out-of-hospital crews were asked to confirm and update the call type, and verify that all patients did indeed meet inclusion criteria for entry into the study protocol.

Daily computer-aided dispatch (CAD) reports of all assignments with the ASTHMA or ASTHMP final call type were entered directly into a Microsoft Access Database (Microsoft, Inc., Redmond, WA), and imported into SPSS for Windows (SPSS, Inc., Chicago, IL) for subsequent statistical analysis. Lists of ambulance call reports (ACRs) requiring collection were generated and faxed to individual battalion stations. Patient assessment and treatment data from returned ACRs

Treatment Protocol:

For patients between one and sixty-five years of age who are experiencing an exacerbation of their previously diagnosed asthma:

1. Assess the airway

2. Administer oxygen

3. Monitor breathing

Note: if patient exhibits signs of imminent respiratory failure refer to the appropriate protocol.

4. Do not permit physical activity.

5. Place the patient in the Fowler's or semi-Fowler's position.

6. Assess the following prior to administration of the first nebulized treatment:

   * vital signs
   * patient's ability to speak in complete sentences
   * accessory muscle use
   * wheezing
   * patient's assessment of severity (Borg scale)
   * peak flow

Note: for patients with a history of angina, myocardial infarction, arrhythmia or congestive heart failure, medical control must be contacted prior to initiating step #7.

7. Administer albuterol sulfate 0.083%, one unit dose of 3.0 cc via nebulizer, at a flow rate that will deliver the solution over 5 to 15 minutes. Do not delay transport to complete medication administration.

8. Begin transport.

Note: for patients in severe respiratory distress, call for advanced life support assistance. Do not delay transport.

9. If symptoms persist, treatment may be repeated once for a total of two (2) doses.

Upon transfer of patient care to an ALS provider or a 911 receiving hospital, reassess the patient. See step # 6.

Note: medical control must be contacted for any patient refusing medical assistance or transport.

Figure 1. Basic life support assessment and treatment protocol.

were entered into the database. Entries were also made for additional ACRs received on those patients meeting inclusion criteria, but whose call types were not updated on the CAD system.

To measure the impact of the study protocol on overall system performance, out-of-hospital time intervals were measured, and requests for ALS backup were identified. For the purposes of comparison and control, similar time intervals were calculated for a three-month period prior to implementation of the protocol. During this time, CROs identified patients meeting the asthma call types (ASTHMA and ASTHMP), and BLS units were dispatched in identical fashion, that is, only when ALS units were not available. There was, however, no protocol for administration of albuterol by EMT-Bs.

Outcome Measures. Outcome measures included the PEFR, the Borg dyspnea index, use of accessory muscles, ability to speak in full sentences, respiratory and pulse rates, and blood pressure. Peak flow measures were presented as percentage of predicted based on height, age, and gender. The Polgar[2] predicted equation was used for patients under age 18 years, and the Cherniack-Raber[3] equation was used for patients aged 18 years and older.

Data Analysis. Data analysis included descriptive statistics and 95% confidence intervals (95% CIs) to describe change in clinical parameters among paired samples after albuterol treatment. To measure the impact of treatment by age on peak flow, categories used by the Fire Department of New York (FDNY) to

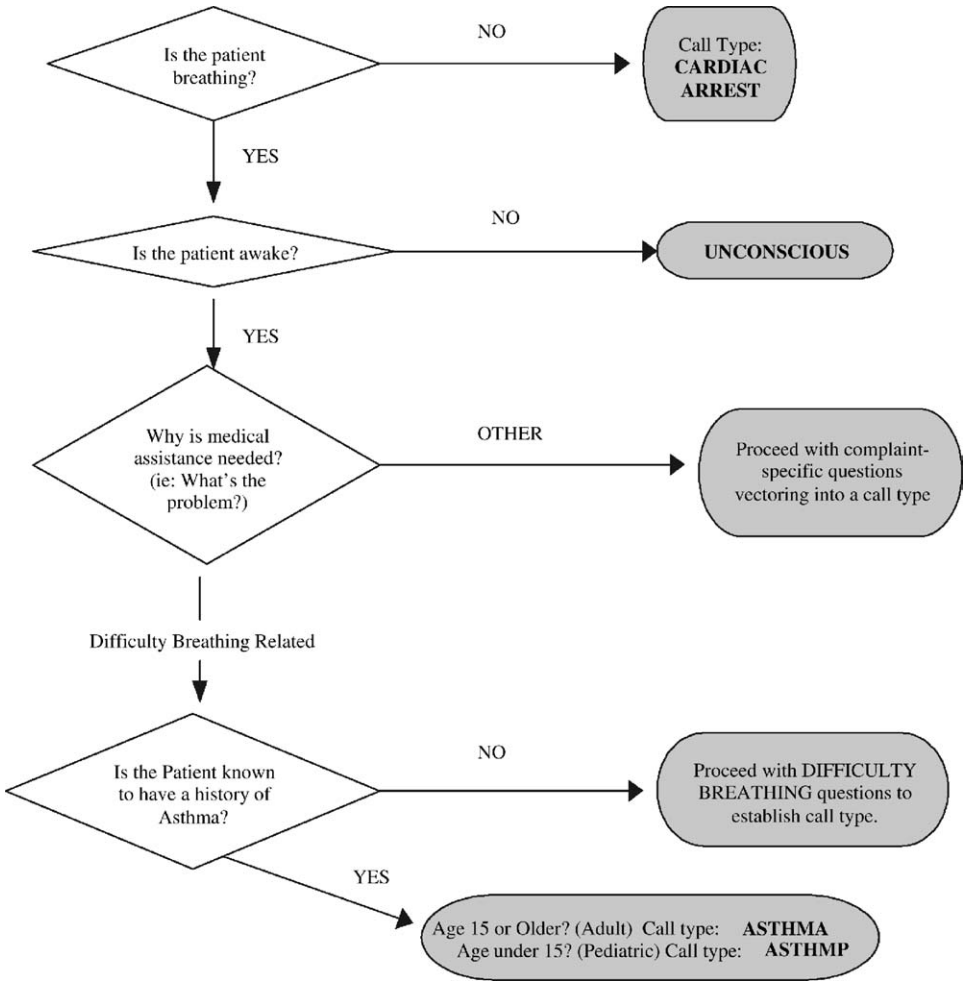

Figure 2. Call receiving algorithm used for asthma 9-1-1 calls in the Fire Department of New York emergency medical services system.

classify pediatric patients (age <15 years versus age ≥15 years) were used.

RESULTS

Characteristics of the Study Subjects. During the one-year study period of January 1, 1999, to January 1, 2000, there were approximately 1.05 million calls to 9-1-1 for EMS assistance, and 800,000 patient transports. There were 36,022 calls for adult asthma (3.4% of all system calls) and 10,944 calls for pediatric asthma (1.0% of all system calls). BLS units were dispatched to 9,961 of these assignments, only when ALS units were not available. A dual ALS/BLS response was subsequently made in 1,847 cases, therefore excluding them from the study. Of the remaining cases, the ACRs were retrievable for data analysis in 4,711 assignments. An additional 406 cases were unfounded or canceled, and 954 cases were excluded per protocol by BLS crews (Table 1). This left a total of 3,351 patients for final data analysis (Figure 3).

The mean age of the patient population was 31 years, with a range of 1 to 65 years, and 60% were female (Table 2). Sixty percent of patients received one treatment and 40% received two treatments. Many of the patients had a history of severe asthma, with a prior history of intubation for asthma found in 22%. Emergency resource utilization for asthma was common, with 81% of all patients having one or more ED

TABLE 1. Reasons for Exclusion from Protocol after Arrival of Basic Life Support (*N* = 954)

Reason	Number
Incorrect call type (non-asthma, but initial call type not changed)	608
Age criteria (age <1 or >65 years)	144
Symptoms resolved	47
Refused medical assistance	44
Treatment already in progress (self/physician/clinic)	42
Past medical history: no asthma	30
Past medical history: cardiac (treatment refused by medical control)	11
Dead on arrival	11
Allergy (albuterol)	5
Treatment refused	5
Respiratory failure	5
Cardiac arrest	1
Medical control (unable to access)	1

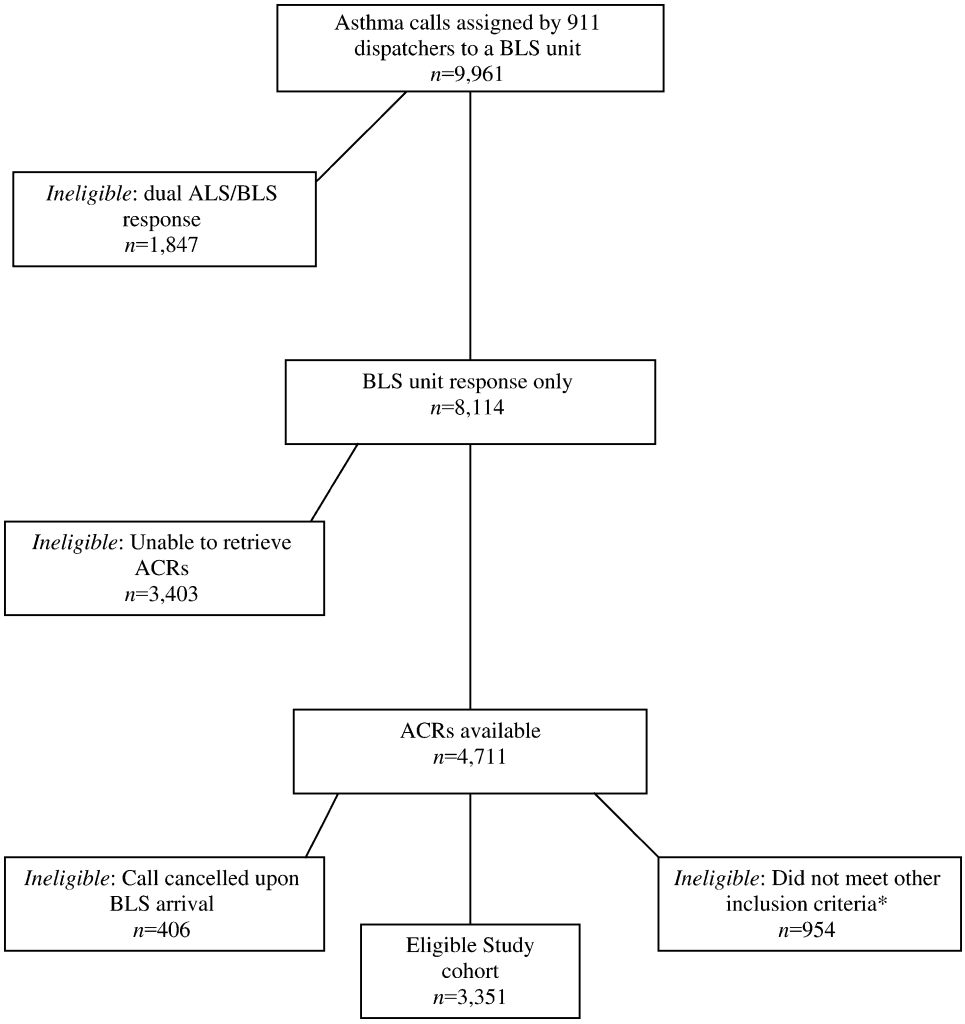

Figure 3. Flow diagram of asthma calls that were included and excluded from the study. *Resolution of asthma on emergency medical services arrival, incorrect call type, signs of imminent respiratory arrest etc. (See Table 1). ALS = advanced life support; BLS = basic life support; ACR = ambulance call report.

visits in the past year, and 47% of all patients hospitalized for asthma at least once in the past year.

Main Results. A total of 2,438 patients had both pre- and posttreatment PEFRs that were recorded in the ACR and analyzable. The pretreatment PEFR was 40.4% predicted and the posttreatment PEFR was 54.8% predicted, yielding an overall 14.4% absolute increase in PEFR % predicted (95% CI = 13.8% to 15.1%) following albuterol administration (Table 3). Posttreatment improvements were also found in all other illness severity parameters, including the dyspnea index, respiratory rate, use of accessory muscles, ability to speak in full sentences, and pulse rate. Analysis of changes in PEFR by age revealed consistent improvements in PEFR among children and adults between pre- and posttreatment measures (Table 3).

Additional subgroup analysis in adults (age 15 years and older) and children (protocol defined as age <15 years) was performed to determine the effect of the intervention in patients with more severe airway obstruction. Among adults with an initial PEFR of 30% predicted or less, PEFR increased from 21.7% to 36.5% predicted, representing an absolute change of 14.8% points (95% CI = 13.8% to 15.9%) and a relative posttreatment improvement of 68%. The Borg dyspnea index decreased from 7.3 to 5.0 (mean change 2.2, 95% CI = 2.0 to 2.4). Among children with an initial PEFR of 30% predicted or less, PEFR increased from 22.5% to 37.5% predicted, representing an absolute change of 14.9% points (95% CI = 11.8% to 18.0%) and a relative posttreatment

TABLE 2. Patient Characteristics (*N* = 3,351)

Age—mean (±SD)	31.3 (±16.5) years
Gender—female	60%
Prior history of intubation	22%
Use of inhaled steroids in past 24 hours	27%
Use of oral steroids in past 24 hours	20%
Number of asthma ED visits in past 12 months—mean (±SD)	5.0 (±10.2); median 2
Number of asthma hospitalizations in past 12 months—mean (±SD)	1.7 (±4.7); median 0

TABLE 3. Clinical Response to Basic Life Support Administration of Albuterol (pre and post Albuterol)

	Pre Albuterol (±SD)	Post Albuterol (±SD)	Mean Change in Value (95% CI of Difference)
PEFR* % predicted, age ≥5 years	40.4% (±21.0)	54.8% (±26.0)	14.4 (13.8, 15.1)
PEFR % predicted, age <15 years	53.1% (±36.2)	73.7% (±51.5)	20.5 (17.6, 23.4)
PEFR % predicted, age ≥15 years	39.1% (±20.7)	53.0% (±24.5)	13.9 (13.2, 14.6)
Respiratory rate—breaths/min	25.3 (±5.0) breaths/min	22.5 (±4.5) breaths/min	−2.8 (−3.0, −2.7)
Dyspnea Index score†‡	6.8 (±2)	4.7 (±2.5)	−2.1 (−2.2, −2.0)
Pulse—beats/min	101 (±18) beats/min	100 (±17) beats/min	−0.8 (−1.1, −0.4)
Systolic blood pressure	130 (±24) mm Hg	128 (±22) mm Hg	−1.3 (−1.6, −0.9)
Accessory muscle use	46%	21%	−25 (−23, −27)
Ability to speak in full sentences†	72%	90%	18 (16, 20)

*PEFR = peak expiratory flow rate.
†Age 5 years or older.
‡Modified Borg dyspnea index 0–10 (0 = least severe, 10 = most severe).

improvement of 66%. The Borg dyspnea index in children decreased from 7.0 to 4.6 (mean change 2.4, 95% CI = 1.9 to 2.9).

The mean (±standard deviation) pulse rate among all patients changed from 101 (±18) to 100 (±18), reflecting a posttreatment difference of −0.80 (95% CI = −1.1 to −0.4). Following treatment the pulse increased by ≥10 beats/minute in 14% of all patients. A decrease in PEFR following albuterol was demonstrated in 4.6% of patients, and an increase in dyspnea (increasing index) was reported in 4.9% of patients.

Respiratory Failure. There were no reported cases of out-of-hospital cardiac arrest among the patients included in the protocol. Four patients who were administered β-agonist treatment by BLS had respiratory insufficiency or respiratory failure requiring assisted ventilation either on scene or en route to the hospital. For three of these patients, ALS backup was obtained, and for one patient, the BLS unit transported the patient without ALS assistance. No ED/hospital follow-up information was available for any of these patients. Five additional cases initially dispatched as ASTHMA required ventilatory assistance upon arrival of BLS and were therefore excluded from the protocol; in four of these cases, ALS backup was obtained.

Out-of-hospital Time Analysis. ''On-scene'' and ''to-hospital transport'' times were utilized to measure the impact of the protocol on overall system performance. For comparison and control, similar measurements were obtained for a three-month prestudy period. The on-scene times in the control period were 15 minutes 47 seconds, compared with 19 minutes 38 seconds in the study period, a difference of 3 minutes 51 seconds. To-hospital transport times were similar (7 minutes 16 seconds control versus 6 minutes 46 seconds in the study period).

Request for ALS Backup. ALS backup was requested by BLS units in 16% of ASTHMA/ASTHMP calls to which BLS units were initially dispatched. Final transport disposition following request for ALS backup was as follows: BLS subsequently transported 56% of these cases without ALS support, ALS assisted transport in 42%, and ALS assisted refusals of medical assistance/transport in 2%.

DISCUSSION

There are nearly 2 million annual ED visits for asthma in the United States, a number that has been rising over the past two decades.[4] With increased utilization of EDs for acute asthma care, there may also be expected a greater reliance on EMS systems for patient stabilization and transport. Prior studies, however, indicate that out-of-hospital management of asthma may be less than optimal.[5,6] One study demonstrated that only 7% of hospitalized asthmatic children receive albuterol treatment in the field.[6] Another, an out-of-hospital survey in New Mexico, found that only 23% of EMS services administer β-agonist therapy.[7] This is of particular concern, given that nebulized bronchodilator therapy is the mainstay of treatment for acute asthma, that delays in the treatment of acute asthma may be harmful, and that the out-of-hospital management of asthma has potential to play a significant role in improving illness severity.

In this study, both subjective and objective clinical parameters were utilized to demonstrate the effective and reasonably safe administration of nebulized albuterol for acute asthma by EMT-Bs. The effectiveness of albuterol administration by EMT-Bs was demonstrated by substantial improvement in all clinical patient assessment measures. There was posttreatment improvement of PEFRs and patients' assessments of their own difficulty breathing. The average initial PEFR was 40% predicted, and this increased following albuterol administration in pediatric and adult age groups. Overall, the study protocol resulted in earlier administration of albuterol, reflecting the average of 23 minutes it took from EMT-B arrival at scene to arrival at the hospital.

The National Asthma Education and Prevention Program (NAEPP) guidelines recommend that ALS

units administer β-agonists but do not address out-of-hospital treatment of asthmatic patients by BLS units.[8] Furthermore, while out-of-hospital studies have demonstrated patient improvement following treatment with β-agonists,[9–12] not all EMS systems utilize standard protocols for this purpose. In those systems that do utilize such protocols, medication administration may also be limited by scope of practice to higher-level providers, who are not always readily available. Reports have addressed the out-of-hospital treatment of asthma by such advanced level providers. A smaller study demonstrated that EMT-Bs can successfully recognize bronchospasm and administer beta-agonist therapy.[13] Our study documented the effective use of such protocols when all EMT-Bs in a large 9-1-1 EMS system are trained to administer β-agonists.

The administration of β-agonist therapy by EMT-Bs might be especially valuable in single-tier BLS systems, or in those multiple-tier systems where ALS resources are limited and therefore not always immediately available. This expanded scope of practice for EMT-Bs could have substantial impact in rural areas with prolonged transport times, or where the initial care of patients might be relegated to other first responder personnel (such as firefighters) who might otherwise have little training and experience in the management of acute asthma. In addition, out-of-hospital treatment may provide reassurance to patients, as well as an increased sense of skill and professionalism among BLS providers.

Medical control was utilized here only for eliciting physician direction in the face of potentially confounding or complicating histories of cardiac-related illness, or for patients refusing medical assistance and/or transport. The study protocol was designed to obviate the need for routine medical direction or even for out-of-hospital providers to make determinations based on clinical parameters of the need for β-agonist therapy. Instead, treatment criteria were based solely on presenting complaint and medical history, thereby eliminating reliance on peak flow values, or difficult-to-assess or -interpret clinical findings such as audibility of breath sounds or the presence or absence of wheezing. Training requirements are therefore also limited in scope, focusing primarily on protocol utilization, and the logistics of medication administration.

Out-of-hospital time intervals, as measured by on-scene and to-hospital transport times, were measured and compared with historical controls, and on-scene time increased by approximately 4 minutes in comparison with that for asthma calls prior to implementation of the study protocol. This delay may have been exaggerated by the additional on-scene history taking and measurements used to document clinical response for purposes of the demonstration project (e.g., past resource utilization, Borg scale, peak flow measures). In practice, a provider could quickly administer a nebulizer treatment while on scene or en route to the hospital after obtaining an abbreviated history and evaluation. Finally, BLS providers did not request ALS backup in 84% of asthma cases to which they were dispatched, suggesting that EMT-Bs themselves are comfortable in the management of acute asthma in most cases.

LIMITATIONS

There are a number of limitations to the study. Because of the known efficacy of β-agonists, it was not feasible to utilize clinical controls. Since neither patients nor BLS providers were blinded to the study medication, it is possible that posttreatment data collection was influenced by knowledge of the intervention. We also did not compare BLS management of acute asthma patients with an ALS or paramedic criterion standard.

This study raises but does not answer the important question regarding the necessity of an ALS response to all acute asthma patients, in anticipation of potential respiratory failure. In the NYC FDNY 9-1-1 system, asthma calls are dispatched to BLS units only when ALS units are not available. During the course of this study, a BLS unit initially responded to 23% of all asthma calls. In nine cases, assisted ventilation was first performed by the BLS provider, with ALS backup requested in seven cases. The lack of a paramedic control group and difficulty in obtaining hospital outcomes of patients who required assisted ventilation prevented efforts to further address these issues. In addition, because of the lack of controls and inability to obtain inpatient records, we were unable to determine whether out-of-hospital β-agonist therapy had any effect on ultimate clinical outcome in the 60 hospitals studied.

Another important limitation was related to data collection in our EMS system. We were unable to retrieve a large number of the ACRs for patients who may have been included in the asthma protocol. Since the asthma data-collection information was printed on the back of the ACR, when the ACR was missing, clinical information on these patients was unavailable. While selection bias on missing data is potentially a concern, the ACRs for asthma are batched with, and handled no differently from, any other call type, and we believe the inability to locate or retrieve the ACRs was random.

CONCLUSIONS

Albuterol can be effectively administered to acute asthmatics by EMT-Bs in a large EMS system. Substantial improvements in subjective and objective out-of-hospital patient assessment measures were demonstrated following treatment. EMS systems

should consider allowing BLS units to administer β-agonists to asthmatic patients out-of-hospital when no ALS units are available, and NAEPP recommendations could reflect this. The scope of the current work might also be broadened to look at the ability of EMT-Bs to assess and treat patients with acute bronchospasm due to chronic obstructive pulmonary disease.

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